Accurate Positions for MCG Galaxies

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ABSTRACT

We have measured accurate celestial coordinates for 4741 extragalactic objects, primarily drawn from a list of MCG galaxies with no recently published accurate positions. The standard deviations in the new positions depend slightly on the measurement method, but are on the order of $1''.0$ to $1''.2$. Standard deviations in the original MCG positions are confirmed to be at the $1'.5$ to $2'.0$ level. These new positions were integrated into NED in December 1997.

Subject headings: galaxies: general — astrometry

1. INTRODUCTION

The *Morphological Catalogue of Galaxies* (MCG, Vorontsov-Velyaminov et al. 1962, 1963, 1964, 1968, 1974) is a compilation of about 30,000 galaxies covering the sky from the north celestial pole to declination = $-45°$. It is based on a visual inspection of the blue prints of the first Palomar Observatory Sky Survey (POSS1). Vorontsov-Velyaminov's original motivation for compiling the MCG was to provide descriptive morphologies for the included galaxies. However, the catalog has found its greatest use as a finding list for detailed studies of individual galaxies and as a source of data for statistical investigations across large areas of the sky. The MCG also

remains the only published galaxy catalog to systematically cover the declination zone $-2\overset{\circ}{.}5$ to $-17\overset{\circ}{.}5$ to 15th magnitude.

The MCG, along with CGCG (Zwicky et al. 1961, 1963, 1965, 1966, 1968a,b), UGC (Nilson 1973), ESO (Lauberts 1982), SGC (Corwin et al. 1985), and a few other specialized galaxy catalogs, formed the starting list of optical galaxies in the NASA/IPAC Extragalactic Database (NED). During the initial work on NED, the MCG galaxies were cross-identified where possible with galaxies in the other catalogs. However, the standard deviations and occasional accidental errors of the original MCG positions are large enough that cross-identifications could not be confidently made in many cases. This is especially true in crowded fields and for the fainter MCG galaxies ($m \lesssim 16$) where the probability of confusion with other (often uncataloged) galaxies is high. This limitation posed major problems for automated (positional coincidence based) methods aimed at cross-indexing the MCG with existing and future catalogs.

Since NED's inception, we have taken improved celestial coordinates from the literature or from more recent catalogs whenever possible. By the spring of 1997, all but 4100 of the MCG galaxies had improved coordinates in NED, either through association with entries in other catalogs, through our literature searches, or through special (though limited) efforts by the NED team (e.g. Spellman et al. 1989, Madore et al. 1994). However, the difficulties of associating increasingly accurate literature positions (often with standard deviations of less than an arcsecond) with the relatively poor MCG positions continued to create enough confusion problems that we decided to measure accurate positions for all of the remaining MCG galaxies. The availability of the Digitized Sky Survey (DSS) from AURA/STScI/ASP, along with IPAC's "Skyview" software[1], made it possible to contemplate completing the project in a reasonable period of time.

This paper describes the procedures we followed while measuring the positions, presents the resulting coordinates, and compares them with existing positions to derive formal standard

[1]Skyview is available on the World Wide Web at http://www.ipac.caltech.edu/Skyview/ or by ftp from ftp.ipac.caltech.edu/pub/software/Skyview/.

deviations.

2. PROCEDURES

We first drew from NED a list of all objects which had the MCG as the best available position source. Assembled in early June 1997, this list contained 4114 entries. We then used STScI's "getimage" program to extract 10′ x 10′ fields from the DSS centered on the nominal MCG positions. One of us (IP) then examined these fields using Skyview, identified the MCG galaxy, and measured its coordinates with Skyview's "pick" command (this returns the coordinates of a single pixel selected by the user as representing the center of a galaxy). If the MCG entry referred to a pair or multiplet of galaxies, we measured each of the individual objects, and also estimated the center of the entire system. In addition, we measured many galaxies mentioned in the MCG notes, as well as other galaxies in the field when we were unsure which object was selected for inclusion in MCG.

Our choice of the "center" of a galaxy image will influence the accuracy of the measured position. Some of the galaxies in our list have small, well-defined nuclei which can be easily seen against the more extended background light of the outer parts of the galaxy. More often, however, the nucleus is lost in the saturated image of a central bulge. In these cases, we estimated by eye the position of the center of the bulge. Some low surface brightness galaxies also have no apparent nuclei. For these, we again estimated by eye the center of a bar if one exists in the galaxy, or the approximate center of the entire image.

Because we used images extracted from the DSS, our positions are implicitly tied to the DSS astrometric calibration. This uses AGK3 stars north of the celestial equator, and SAO stars south to the MCG southern limit of $-45°$. In Section 3, we show that the DSS calibration is consistent with the positions given in the Lick Observatory list of reference galaxies for their northern proper motion survey (NPM1G; Klemola, Jones, and Hanson 1987). This is the expected result as the Lick survey also uses AGK3 positions for its astrometric calibration (south of the equator, Lick

uses Perth 70 positions).

We also note that the DSS assigned the origin of the scan on each plate to the southeastern corner of the southeastern pixel, rather than to the center of that pixel. With a pixel size of 1.″7, this means that a systematic diagonal shift in the measured positions of 1.″2 would be possible depending on the origin assumed by the software used to calculate the positions from the FITS header. The version of Skyview that we used was sensitive to this effect; see Section 3 below.

In many cases, the identity of the MCG galaxy was ambiguous, and in some instances, there was no object in the 10′ x 10′ field matching the MCG description. One of us (HC) subsequently examined each of these problematic cases on the blue POSS1 prints and found it possible to make a positive identification of the "missing" MCG objects in all but eleven cases (see Table 1). We then extracted 10′ x 10′ fields from the DSS centered on corrected positions estimated from the POSS1 prints, and measured accurate coordinates for the newly-identified galaxies. HC used Skyview's "examine" command to find flux-weighted centroids for the brighter portions of the galaxy images (defined by ellipses placed by eye).

Finally, we merged the data into NED following our usual procedures. We searched NED within 5′ around the newly-determined accurate positions, and logged matches and possible matches with existing NED objects. We again examined ambiguous cases on further DSS cutouts, or on the POSS1 charts, until we were satisfied that the MCG entry was correct or adequately explained. Most of the major discrepancies we found were due to incorrect MCG positions from

1. simple digit errors (e.g. 10′ or 1.^{m}0),
2. systematic offsets of the MCG positions in either or both of the published coordinates within a single field,
3. transcription errors (e.g. +55° rather than +50°), or
4. errors of unexplained origin. In these cases, we were usually guided to the correct galaxy by the MCG diameters, descriptions, and notes.

In addition, we found many of the MCG entries to be original plate (or subsequent print) defects on the blue POSS1 prints, and several others (particularly in the $-36°$ and $-42°$ "Whiteoak" zones) to be single or multiple stars. We attached "Essential Notes" to the NED entries for all of these objects explaining the problems and likely solutions.

Several MCG objects resisted identification altogether; these are listed in Table 1 with possible explanations.

3. ACCURATE POSITIONS, AND STANDARD DEVIATIONS

In all, we measured 5078 positions for about 4100 MCG galaxies, and about 600 components or companions; several hundred of these have been measured more than once. The positions are available through NED, or from the data centers[2]. Table 2 is an example listing of the data, formatted exactly as is the electronic table. The columns are 1) name of the galaxy as it appears in NED, 2) right ascension and 3) declination for J2000.0, and 4) coded source for the position: 1st character, "P" for those measured using the "pick" command, "E" for those measured using the "examine" command; and 2nd character, "E" for the POSS1 red plates, "J" for the SERC blue–green plates.

We compared the original MCG positions with our newly measured accurate positions. We also compared the new positions with the very accurate (standard deviations on the order of $0\farcs3$) positions from NPM1G. Finally, a triangular comparison of the resulting standard deviations of the differences gave an estimate of the "true" external standard deviations in our new positions. The comparisons are shown in Figures 1–3, and in Tables 3–6.

We summarize the results of the comparisons as follows:

1. The original MCG positions have standard deviations on the order of $1\farcs5$ to $2\farcs0$ in both

[2]Astronomical Data Center: http://adc.gsfc.nasa.gov/ or Centre Données Astronomique de Strasbourg: http://cdsweb.u-strasbg.fr/ .

coordinates when the large differences from accidental errors are rejected. There appears to be a small but statistically significant declination offset in the original MCG positions of about 10″ to the south. The MCG right ascensions show no significant offset.

2. Our new positions measured with Skyview's "pick" command are on essentially the same astrometric system as the Lick reference galaxy positions, and have standard deviations of 1.″1.

3. Our new positions measured with Skyview's "examine" command are systematically offset by about one arcsecond to the southeast from the NPM1G positions and from the positions estimated from Skyview's "pick" command. The standard deviations, though, are 0.″8 for the positions from the "examine" command.

   The offset comes from the different algorithms (one based on floating point numbers, the other on integers) used in the "pick" and "examine" commands in the version of Skyview that we used (R. B. Hartley, private communication), combined with the half-pixel offset of the origin for each DSS plate as noted in Section II. We have chosen to not correct either set of positions because the systematic difference is too small to affect identification of the correct galaxies.

4. We note that the standard deviations found by comparison with the Lick reference galaxies almost certainly represent lower limits. The Lick galaxies were specifically chosen to have bright compact nuclei which are easily measurable. Many MCG galaxies fit this description, of course, but many others have diffuse or bar-like central regions without an obvious nucleus. These galaxies will clearly have less accurate positions than those with well-defined nuclei. Thus, the true standard deviations in our new positions will be somewhat larger than the comparison with the Lick positions suggests. So, we have adopted 1.″2 for the "pick" positions, and 1.″0 for the "examine" positions. Therefore, the 95% confidence intervals used in NED are 3.″0 and 2.″5, respectively.

4. CONCLUSION

Using IPAC's "Skyview" program to examine images cut from the DSS, we have measured accurate positions for 4741 galaxies drawn primarily from MCG. The estimated standard deviations are 1.″0 or 1.″2 depending on the measurement method used. We have put the data into NED, and we have also updated NED's DSS images using the revised positions.

We thank the IPAC Skyview team, Booth Hartley in particular, for their extremely useful program and for their comments on its operation. Skyview was produced at IPAC under NASA contract NAS7-918. Similarly, we thank the Space Telescope Science Institute for providing the Digitized Sky Surveys; these were produced at the STScI under U.S. Government grant NAG W–2166. The images of these surveys are based on photographic data obtained using the Oschin Schmidt Telescope on Palomar Mountain and the UK Schmidt Telescope at Siding Spring. D.–C. Kim was supported by NASA contract NAS7-1260. Brian Skiff at Lowell Observatory verified or corrected several of our identifications, particularly on the Whiteoak Atlas prints. The NASA/IPAC Extragalactic Database (NED) is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

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Fig. 1.— New positions minus original MCG positions in arcminutes. Note the groups of points at $\pm 10'$ in declination; these result from typographical errors in the original MCG positions. Similar typographical errors in right ascension are scattered along that axis by the cosine δ term. Forty five points with differences larger than $\pm 30'$ lie outside the limits of the figure.

Fig. 2.— "Pick" positions minus "examine" positions in arcseconds (all points are plotted). The systematic offset is discussed in the text. The clumps of points are the result of the $1\farcs7$ pixel size of the DSS. Note the change of scale between this figure and Figure 1.

Fig. 3.— Lick positions minus "pick" positions (dots) and "examine" positions (circles), in arcseconds (all points are plotted). Note the change of scale between this figure and Figure 2.

Table 1. MCG objects not recovered

MCG	MCG position (1950)	Possible explanation
+12-07-011	06 20.9 +74 27	Perhaps a duplicate of MCG +12-10-007 with 10^m and 10′ errors in the position.
+11-01-001	00 32.0 +65 11	Perhaps the plate defect at 0031.6 +6534 (1950).
+11-04-001	02 37.0 +66 16	Not identified. Several reflection nebulae nearby including MCG +11-04-002 = VDB 008.
+11-09-019	06 50.0 +64 21	Possibly = NPM1G +64.0017 at 0649.7 +6423 with incorrect diameters and description.
+09-20-166	12 22.2 +52 12	Duplicate of MCG +09-20-158?
+08-09-002	04 40.4 +47 54	Perhaps the plate defect at 0440.6 +4846 on the blue POSS1.
+07-28-019	13 27.0 +41 33	Probably = MCG +07-28-018 at 1326.95 +4134; only a single galaxy at the position.
+07-41-004	20 05.3 +44 23	Not identified. MCG notes this as the parent galaxy of a 1959 supernova; no supernova from 1959 is currently cataloged at this position.
+00-60-014	23 33.0 −01 25	B. Skiff (private commumincation) notes this as a plate flaw; the flaw is not on IPAC's copy of POSS1.
−07-04-003	01 21.6 −44 48	Snow (1970) calls this a chain of 4 galaxies. There is a sparse group near the position, but no chain.
−07-04-029	01 39.6 −38 48	B. Skiff (private communication) notes a "linear streak near nominal position. Does not match MCG description."

Table 2. Accurate positions[a]

Name	RA (J2000.0)	Dec (J2000.0)	Source
MCG −01-01-015	00 00 05.01	−05 12 32.0	PJ
MCG −01-01-017	00 00 11.14	−05 09 31.7	PJ
MCG −01-01-019	00 00 27.56	−07 52 55.8	PJ
MCG −01-01-021	00 00 48.54	−05 34 46.9	PJ
MCG +06-01-003	00 00 55.68	+34 38 52.9	PE
MCG +02-01-013	00 01 29.55	+13 05 54.6	PE
MCG +05-01-026	00 01 34.59	+31 26 36.2	PE
MCG −01-01-022	00 01 45.25	−04 20 47.2	PJ
MCG −01-01-023	00 01 48.88	−04 20 35.2	PJ
MCG −02-01-009	00 02 06.12	−10 13 04.8	PJ
MCG −01-01-026	00 02 48.80	−03 36 22.9	PJ
MCG −02-01-012	00 03 22.33	−10 46 13.6	PJ
MCG −01-01-027	00 03 35.59	−07 41 23.6	PJ
MCG +09-01-002	00 03 38.26	+51 46 41.6	PE
MCG +09-01-003	00 03 51.32	+51 43 37.9	PE
MCG −02-01-015	00 04 00.63	−11 10 40.0	PJ
MCG −03-01-017	00 04 12.10	−14 31 24.0	PJ
MCG +06-01-010	00 04 20.84	+37 58 31.2	PE
MCG −01-01-029	00 04 38.02	−08 05 00.4	PJ
MCG +07-01-004	00 04 47.71	+41 44 10.4	PE
MCG −06-01-018	00 04 59.32	−35 40 58.7	PJ
MCG −01-01-028	00 05 05.38	−07 05 36.2	PJ
MCG −02-01-020	00 05 35.25	−13 35 27.7	PJ
MCG −02-01-021	00 05 38.65	−13 36 04.8	PJ
MCG −01-01-032	00 05 48.18	−07 37 43.4	PJ
MCG −02-01-022	00 05 56.35	−13 58 42.8	PJ
MCG −02-01-023	00 05 56.73	−13 59 45.7	PJ
MCG +06-01-011	00 07 02.51	+38 11 00.3	PE
MCG +00-01-027	00 07 10.81	−00 24 53.7	PJ
MCG +05-01-033	00 07 30.58	+28 41 18.2	PE
MCG −04-01-017	00 07 30.98	−20 43 52.6	EJ
MCG −02-01-026	00 07 31.29	−11 47 53.3	EJ
MCG −02-01-027 NED01[b]	00 07 43.88	−11 50 31.2	PJ
MCG −02-01-027 NED01	00 07 44.04	−11 50 32.0	EJ
MCG −02-01-027	00 07 44.26	−11 50 27.6	EJ
MCG −02-01-027 NED02	00 07 44.50	−11 50 25.4	EJ

Table 2—Continued

Name	RA (J2000.0)	Dec (J2000.0)	Source
MCG −01-01-039	00 09 00.45	−02 22 56.0	PJ
MCG +05-01-035 NED01	00 09 00.88	+27 47 01.7	EE
MCG +05-01-035 NED02	00 09 01.01	+27 47 05.1	EE
MCG +05-01-035 NED02	00 09 01.01	+27 47 05.1	PE
MCG +04-01-032	00 09 04.39	+27 43 46.2	EE
MCG +00-01-029	00 09 12.46	−01 18 59.2	PJ
MCG +00-01-030	00 09 36.50	+00 53 09.0	PJ
MCG −01-01-041	00 09 56.16	−07 52 22.9	PJ
MCG −01-01-042	00 10 06.65	−06 19 17.2	PJ
MCG −01-01-044	00 10 23.28	−07 05 03.8	PJ
MCG −01-01-046	00 10 36.74	−04 50 35.3	PJ

[a]The full table is available from NASA's Astronomical Data Center: http://adc.gsfc.nasa.gov/ or from Centre Données Astronomique de Strasbourg: http://cdsweb.u-strasbg.fr/ . This sample page shows the form and content of the full table.

[b]We append the "NEDnn" notation to create unique names in the database when the original catalogs do not include separate entries for double or multiple objects.

Table 3. Comparison between new positions and MCG positions[a]

Sample	Mean difference[b]	Mean error of mean	Standard deviation	N
$\Delta < 7'$	$+0'.018$	$\pm 0'.017$	$\pm 1'.157$	4373
	+0.159	±0.016	±1.074	
$\Delta < 10'$	+0.031	±0.019	±1.280	4418
	+0.144	±0.019	±1.290	
$\Delta < 15'$	+0.014	±0.022	±1.479	4456
	+0.155	±0.023	±1.546	
$\Delta < 30'$	+0.012	±0.025	±1.652	4475
	+0.118	±0.030	±1.977	
All	−0.019	±0.148	±9.926	4520
	+0.210	±0.173	±11.607	

[a]First line is ΔRA, second line is ΔDec.

[b]New position minus MCG position.

Table 4. Comparison between "pick" positions and "examine" positions[a]

Sample	Mean difference[b]	Mean error of mean	Standard deviation	N
All	$+0''.606$	$\pm 0''.082$	$\pm 1''.440$	312
	−0.737	±0.079	±1.400	
$\Delta < 6''$	+0.653	±0.073	±1.278	309
	−0.708	±0.076	±1.330	

[a]First line is ΔRA, second line is ΔDec.

[b]"Pick" position minus "examine" position.

Table 5. Comparison between Lick positions and new positions[a]

Sample	Mean difference[b]	Mean error of mean	Standard deviation	N
Pick	−0.″047	±0.″140	±0.″838	36
	−0.270	±0.167	±1.000	
Examine	−0.772	±0.105	±0.575	30
	+0.553	±0.106	±0.579	

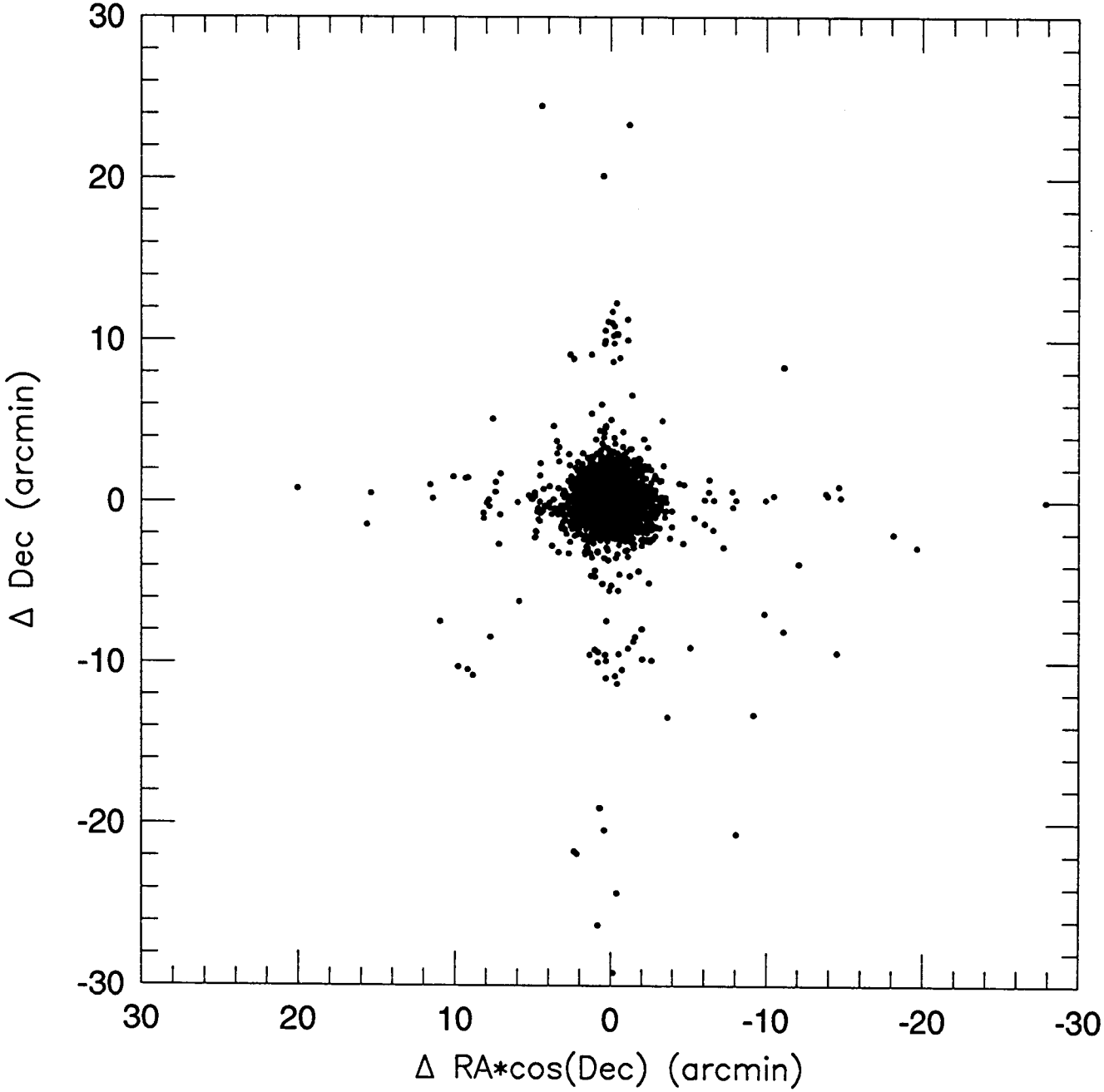
[a]First line is ΔRA, second line is ΔDec.

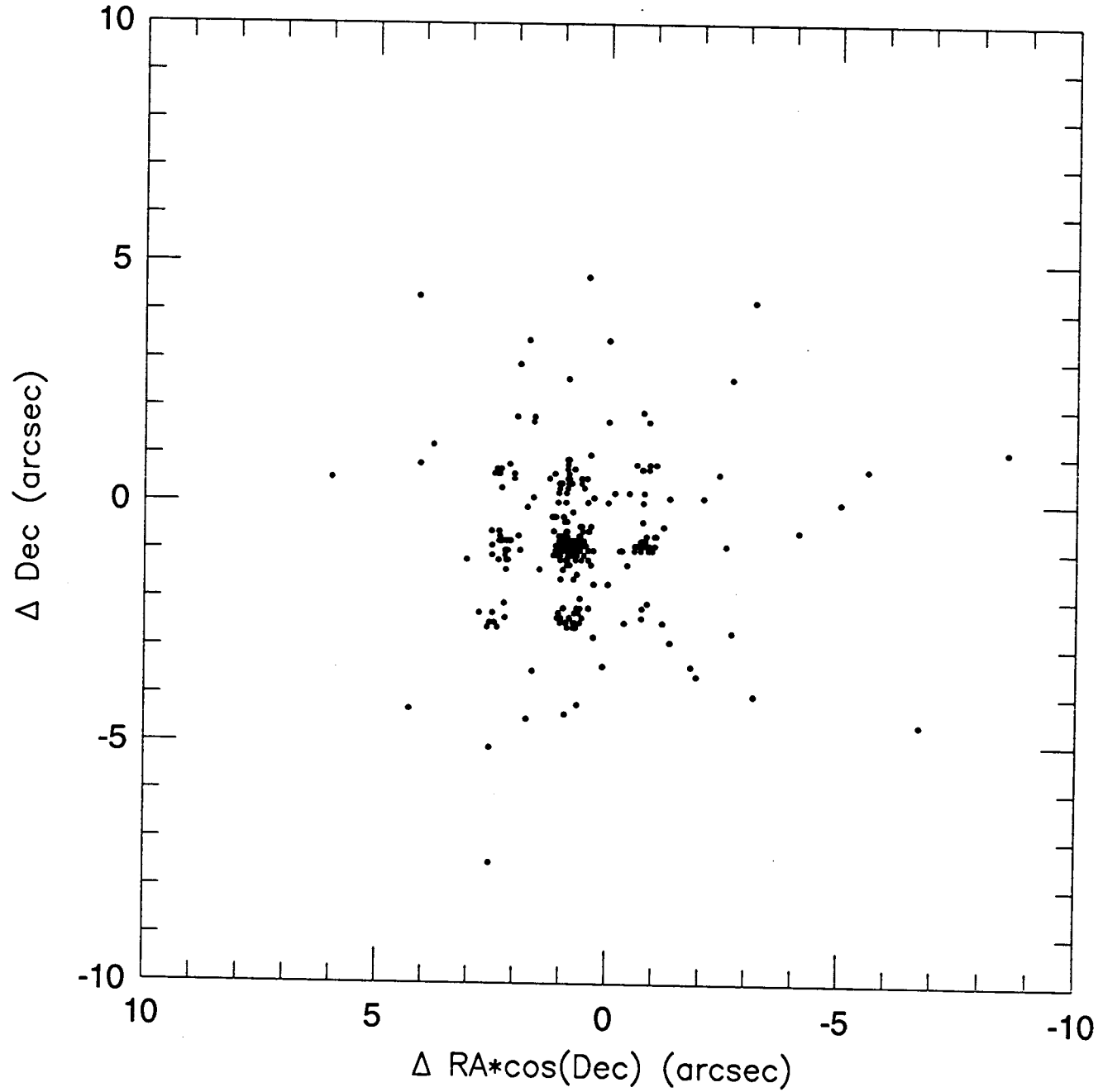
[b]Lick position minus new position.

Table 6. Results of triangular comparison[a]

Sample	"True" standard deviations
Pick	±1.″00
	±1.10
Examine	±0.79
	±0.74

[a]First line is σ_{RA}, second line is σ_{Dec}.


30
20
10
0
-10
-20
-30
Δ Dec (arcmin)
30
20
10
0
-10
-20
-30
Δ RA*cos(Dec) (arcmin)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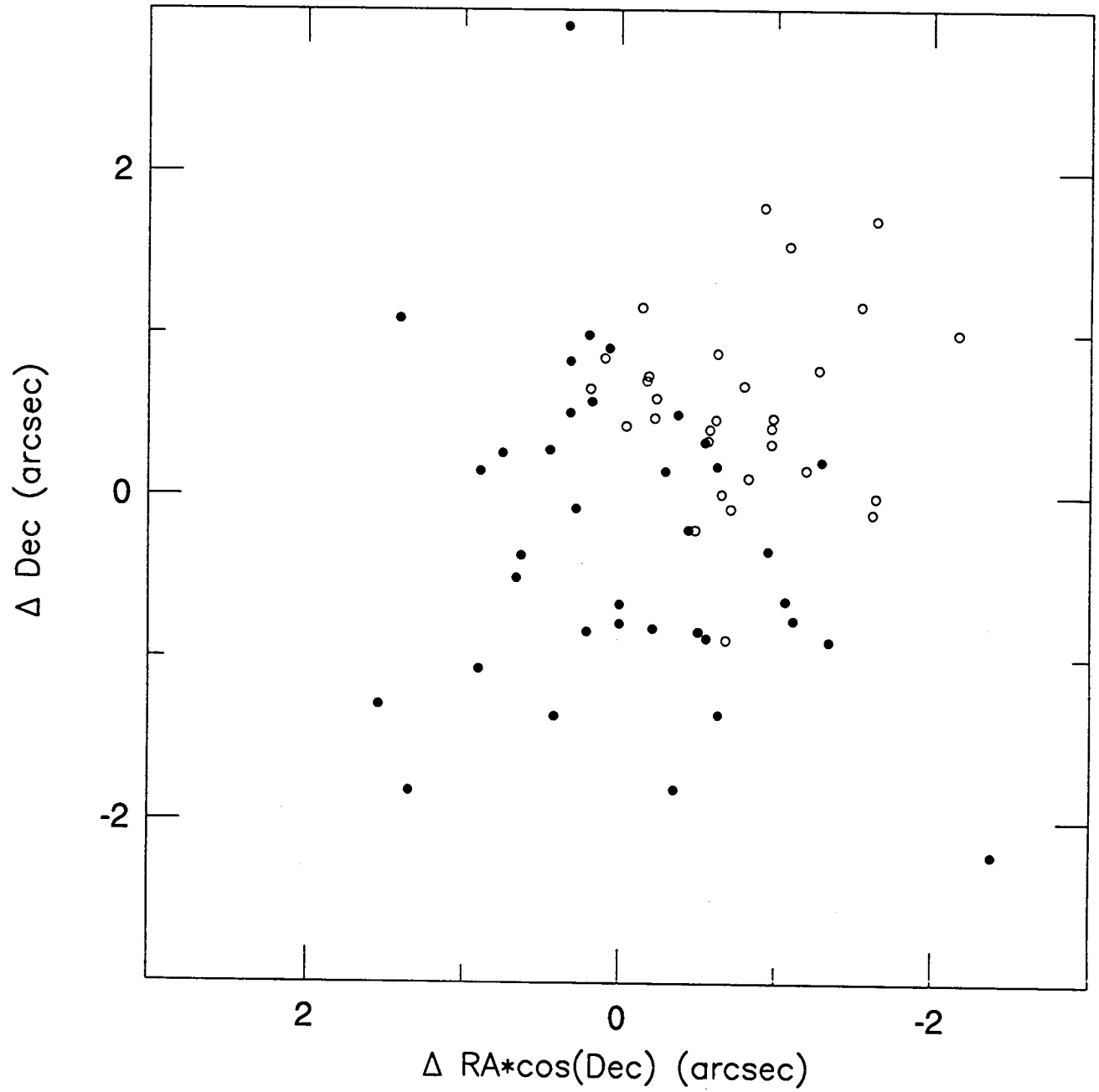
0
-5
-10
Δ Dec (arcsec)
10
5
0
-5
-10
Δ RA*cos(Dec) (arcsec)


2
0
-2
Δ Dec (arcsec)
2
0
-2
Δ RA*cos(Dec) (arcsec)